NASA SOFTWARE OF THE YEAR SUMMARY EVALUATION DOCUMENT

Identification Information	
Software Title:	Collaborative Information Portal (CIP)
NASA Case No.	
Responsible Center(s):	NASA Ames Research Center

Software's Developmental Status	
Current Technology Readiness Level:	9

Significance to NASA Mission Part A - Impact on NASA's Mission

CIP is Class A, Mission–Critical software for NASA's Mars Exploration Rovers Mission (MER) mission. Mission personnel of various roles — managers, technicians, engineers, scientists, and researchers — use CIP at all locations — inside the mission control room, within JPL, and worldwide outside of JPL, in users' offices, homes, and hotel rooms.

CIP is the master clock and the keeper of the master schedules for the mission. Inside the mission control room at JPL, two MERBoards up front display CIP clocks that show times in various Earth and Mars time zones. The big wall screens display CIP schedules. Mission technicians and engineers often display CIP clocks, schedules, and other tools on their workstations. The science rooms at JPL often have MERBoards and wall screens displaying CIP clocks and schedules. Scientists and researchers everywhere use all the CIP tools on their desktop and laptop computers.

The nominal mission for each rover lasts only 90 days, and yet each has already accomplished much, with still more to come. CIP continues to be a significant and critical tool to ensure that during this time, mission personnel work together efficiently and effectively.

Significance to Science, Technology, & Industry in General Part B – Impact on Science & Technology

MER has been phenomenally successful. Both rovers, Spirit and Opportunity, continue to send billions of bytes of data and images from Mars to Earth, and they are making discoveries that will keep scientists busy for years to come. NASA scientists and researchers use CIP to download data and image files generated by the rovers, and to analyze these files collaboratively.

CIP validated several key design principles that future NASA software products can use:

- Platform independence.
- Component–based software architecture.
- Commercial off–the–shelf software.
- Industry standards.
- Three–tier enterprise architecture.
- Service–oriented middleware.
- Web services.

Significance in Impact on the Quality of Human Life Part C

Most MER mission personnel worked on Mars time. Because each Martian day is about 40 minutes longer than an Earth day, regularly scheduled events shifted day to day relative to Earth time. This imposed a major hardship on family lives.

CIP allows mission personnel to consult times and schedules from their homes to determine when they need to come into JPL. They can be with their families as much as possible without worrying about missing important meetings or rover events. CIP is able to download data and image files through the JPL firewalls, and so people can do significant work at home.

Extent of Current and Potential Use

We designed and developed CIP for the MER mission. Mission personnel in various roles use CIP both inside and outside of the mission control room, and both on and off the JPL campus. There are over 330 registered CIP users, and over 250 copies of the CIP application installed on desktop or laptop computers. CIP's middleware also supports two other MER applications, Viz and Quill.

CIP is the primary time management tool for the mission, both for operations and for science. CIP times and coordinates all communications events inside the mission control room. CIP is a key tool for retrieving rover data and images through JPL's mission firewall. As of March 31, 2004, CIP had downloaded over 100 GB to users' local desktop and laptop computers.

There are always two MERBoards in the front of the mission control room that display CIP clocks, usually the two Mars times (one in each rover's time zone) and Earth time UTC. The flight director often has a CIP schedule displayed on several of the large wall screens. Many of the control room engineers have CIP applications running on their workstations. They can display a schedule of the currently active rover similar to the one up on the big screens, or perhaps a staffing schedule that shows who is working where, when, and in what role. The engineers also use the Time Conversion tool to convert between Mars and Earth times.

Mission scientists and researchers who have accounts can use CIP on their desktop or laptop computers at JPL or in their homes, offices, or schools anywhere in the world as long as they also have VPN access into JPL. For these users, CIP is their primary means of keeping track of Mars time, viewing the current schedules, and receiving broadcast messages. Most importantly, CIP allows them to download rover data and images through JPL's mission firewall to their local computers for viewing and saving.

As work complexity grows, it will be more and more difficult to shoehorn users into a few rigid applications. Software and systems will need to be more adaptive to the computing environment and user needs. CIP adapts by automating data acquisition and schedule correlation. Its middleware services are dynamically reconfigurable. These aspects of CIP will be useful for future commercial and government applications.

Usability of the Software – 20% of Creativity Score

CIP successfully serves two distinct classes of users. Mission managers and engineers working inside mission control at the Jet Propulsion Laboratory (JPL) are responsible for controlling and communicating with the rovers during daily operations. Mission scientists and researchers working at JPL and worldwide plan each rover's operations, and they analyze the data and images downloaded from the rovers. People are organized into two teams, one per rover, although often people move from one team to the other. They all work on Mars time, and each person can have different roles at different times. While CIP has crosscutting functionality that makes it useful for both classes of users, its user–oriented innovations make people want to use it. CIP users can view current event and staffing schedules, download data and image files generated by the rovers, receive broadcast messages, and get accurate times in various Earth and Mars time zones. People rely on it throughout all stages of daily mission operations, whether they were working inside mission control or in the science areas at JPL or throughout the world.

We did not build CIP and its user interfaces in a vacuum. We worked closely with the Human Factors experts. We evolved CIP from early prototypes to its final version by personally participating in a series of Operational Readiness Tests at JPL to collect user feedback, which we analyzed and prioritized for each next version of CIP. This process of working closely with users to solicit their feedback is, unfortunately, atypical of most software development projects.

CIP's service–oriented architecture enables it to be used everywhere. We designed an innovative three–tier enterprise architecture to meet the goals of scalability, reliability, extensibility, and security. Partitioning the application into a client tier, a middleware tier, and a data repository tier balances and distributes the computational resources. A centralized set of servers provides services to all the CIP client applications.

Usability of the Software (Continued)

User testimonials about CIP include statements such as

- "the most number one helpful tool that I've had"
- "the one ubiquitous tool that everybody looks to find out when things are happening on the project"
- "really useful to help me understand where we are in the process"
- "mostly it's just integrated into what we do everyday"
- "I have found the CIP software system indispensable"
- "It would have been extremely difficult to conduct our challenging rover operations without it"
- "I expect it will be used on other missions from now on"

Prior to the mission, we conducted several user training sessions. During the entire mission, we have been providing mission personnel with 24 X 7 support, both on–site and by phone.

Quality Factors Considered in Software – 40% of Creativity Score

CIP's performance has been excellent throughout the MER mission. Since it became operational in mid December 2003, CIP has been running 24 hours/day. It has been non-operational less than five hours, for an up–time of better around 99.8%. At JPL, the mission control and science assessment areas have continuously maintained CIP clocks and schedules during this entire time. CIP has delivered over 100GB of file data to users.

Our innovations that increase reliability include extensive runtime logging, real time monitoring, and intensive stress testing. A key innovation that allows CIP to stay up and running for long periods (over 41 days at a time) is dynamic reconfiguration. CIP's middleware design allows individual services to be hot redeployable. In other words, we can restart a service while the rest of the middleware (and CIP as a whole) continues to run.

We built CIP according to industry standards, such as the Java 2 Enterprise Edition (J2EE) and web services. We used several key commercial off–the–shelf components, such as BEA's WebLogic application server. Industry standards and a component–based architecture make the parts of CIP reusable and interchangeable.

As CIP's developers, we overcame major challenges:

- CIP is task oriented and user oriented. CIP performs many tasks that enable its users to do their jobs. It also must be intuitively easy to use. We continually solicited and responded to user feedback.
- CIP is scalable. It accommodates ever-increasing numbers of users and user requests without significant performance degradation.
- CIP is extensible. Requirements and specifications constantly evolved. The mission added new tasks, and it removed obsolete tasks. The CIP architecture makes adding and removing code modules straightforward.
- CIP is reliable. A mission–critical application in use everywhere by everyone must minimize downtime.
- CIP is secure. It complies with JPL's security constraints to protect the downloaded images and data.
- CIP is adjustable. Day–to–day operational parameters often change during the mission, such as the current value in seconds of one-way light time from Earth to Mars. CIP adjusts to these changes while continuing to run.
- CIP is flexible. It supports multiple computing platforms and interaction models.

Quality Factors Considered in Software (Continued)

According to testimonials from the mission staff, the major values that CIP provides them include:

- Time savings.
- A quick and easy way to retrieve any pertinent documents or data products.
- Situational awareness or the time management aspect of correlating time, events, and staffing.
- Answers to the questions: What's going on? What do I need to do? How long do I have to do it? Who's on staff and in what roles? What time is it? What time will it be? When will the next communications passes occur? Where are we in each rover's daily timeline?

Quality Factors Considered in Software (Continued)	

Efforts to Transfer/Commercialize Software – 10% of Creativity Score	
Description of Plan/Strategy to Transfer/Commercialize Software	The success of CIP for the MER 2003 mission is encouraging other NASA projects to consider using versions of the application, or adopting its infrastructure design. At this stage, we have begun discussions with several NASA centers that have projects that need the capabilities that CIP provides. We have also met with the U.S. Navy.
NASA Intellectual Property Status/Potential	The CIP project has filed several invention disclosures: • Synchronized multi-planetary clock • File system navigation with automatic file characterization • A mechanism for coalescing schedules • Varying detail in schedule presentations • Schedule building algorithm
Commercialization Potential for the software.	Not applicable at this time.
Dates Software released for commercial use	Not applicable at this time.
List all existing licenses and/or partnership agreements for the software	Memorandum of Agreement with JPL/MER.

Innovation – 30% of Creativity Score

CIP has achieved *ubiquitous computing* — everyone uses CIP everywhere — because we were highly innovative. Everyone uses CIP because of our user–oriented innovations. Everyone uses CIP everywhere because of our architectural innovations.

The user–oriented innovations that support ubiquitous computing include:

- Martian timescales in the schedule viewer.
- Adaptive timescales in the schedule viewer.
- Now bar and time scrolling in the schedule viewer.
- Schedule coalescing.
- Schedule correlation.
- Absolute or symbolic schedule retrieval times.
- Multiple data viewing modes.
- Use of metadata.
- Clock synchronization.
- Multiple computing platforms and interaction modes.
- Color coding.
- Network health indicators.

The architectural innovations that support ubiquitous computing include:

- Designing CIP to be a three–tier enterprise application.
- Adhering to industry standards.
- Using commercial off–the–shelf software.
- Using web services as the interface between the client applications and the middleware.
- Extensive runtime logging, real time monitoring, and stress testing of the middleware.
- Dynamically reconfigurable services.
- A separately managed data repository tier.
- Using JMS for asynchronous messaging.